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(71) Applicant: **A. AHLSTROM CORPORATION**

SF-29600 Noormarkku (FI)

(72) Inventor: **Manninen, Matti**
Hirventie 3
SF-48230 Kotka (FI)
Inventor: **Peltonen, Kari**
Isantamiehentie 20d
SF-48400 Kotka (FI)
Inventor: **Vesala, Reijo**
Lohniementie 29
SF-48300 Kotka (FI)

(74) Representative: **Füchsle, Klaus, Dipl.-Ing. et al**
Hoffmann, Eitle & Partner,
Patentanwälte,
Arabellastrasse 4
D-81925 München (DE)

(54) **Method and apparatus for mixing gaseous chemical to fibre suspension.**

(57) The present invention relates to a method of and an apparatus for mixing large amounts of gas with medium consistency (8 - 25 %) fiber suspensions by means of rotatable rotor arranged within a mixing chamber provided with various mixing members, the method mainly comprising the steps of a) introducing said gas and said fiber suspension into the mixer, b) mixing said gas with the fluidized pulp while simultaneously throttling the flow in order to prevent the influence of the pressure fluctuations due to the inlet and/or outlet flow of the fiber suspension on the mixing process and minimizing gas separation, and c) discharging the gas-fiber suspension mixture from the mixer.

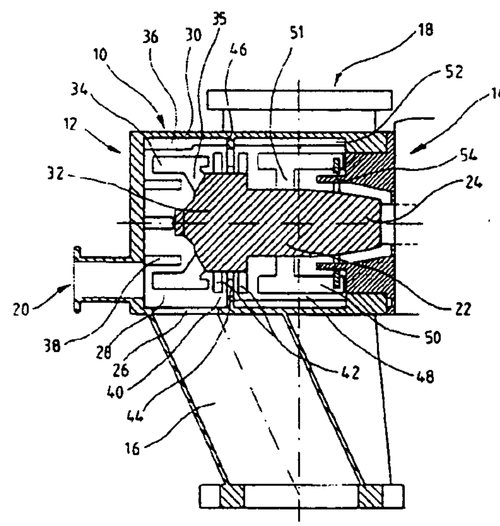

FIG. 1

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The present invention relates to a method applicable for the use described in the preamble of claim 1 and to an apparatus basically described in the preamble of claim 5. The invention especially relates to the mixing of a large amount of gas with a fibre suspension. The purpose has been to develop a method of and an apparatus for mixing ozone gas entrained with a carrier gas into a fiber suspension, yet not excluding the use of other chemicals. The method and apparatus in accordance with the present invention may especially be applied to mixing ozone with medium consistency (consistency 8 - 25 %) fibre suspensions.

Bleaching plants today have a need to mix large amounts of gas with a fibre suspension. Also since the consistency of the fibre suspension is approximately 10 to 15 %, it must be possible to mix a large volume of gas with the medium consistency. In other words, during the mixing process, the medium contains approximately 40 to 80 % fibre suspension and approximately 20 to 60 % gas, most usually, however, approximately 30 to 50 %. To evenly feed such a large volume of gas into a medium consistency fiber suspension and to achieve a good mixing result is difficult, since the gas separates due to local pressure differences to an area with lower pressure, if possible. This results in an increased chemical loss, an uneven bleaching result, and a weakened process runnability.

A number of known mixers are used, for example, for mixing ozone. Some of these mixers have previously been used for mixing liquid chemicals and which may also have been used for mixing gaseous chemicals. Typically, the mixers are efficient only when mixing relatively small gas volumes. Such mixers have operated satisfactorily with several gaseous chemicals used in bleaching. Attempts have also been made to use them for mixing ozone. It has been noted, however, that although a mixer has been able to satisfactorily mix small amounts of gas with a fibre suspension, the mixing of large amounts of gas, for example 10% or more, has not been successful. Several of the above mentioned mixers have been modified for mixing large gas amounts, but this has typically resulted in poor, completely unsatisfactory, mixing results.

Another group of the prior art mixers is formed by recent apparatuses especially designed for mixing large ozone gas volumes. Many of these have reached the development point by now, where the prototype is brought to a mill and tested in mill scale. The results have typically been more positive than with the previously known modified mixers. However, according to those who know the potential possibilities of ozone in the bleaching art, even the modern ozone mixers do not operate more than satisfactorily in mill scale. A phase has thus been reached where the pulp mills are rather satisfied with the achieved bleaching result and th relation thereof to the investments required by the implementation of ozone bleaching.

However, the development staffs both in the apparatus and method fields are of the opinion that the mixing process may be improved considerably. Research has proved that the mixing process is in many cases not efficient enough or that the mixture of ozone and fibre suspension generating as a result thereof is not homogeneous enough. This may become evident in many ways. It is possible that the pulp is bleached inhomogeneously and a portion of the pulp is deteriorated, whereby too much ozone has been dosed for the pulp unit in question, and whereby a portion of the pulp has remained without a sufficient portion of ozone thus becoming only partially bleached. It is also possible that in the gas separation carried out after the bleaching reaction more ozone is separated from the pulp, which in practice means that the ozone has not yet sufficiently mixed with pulp or that the ozone has not had enough time to react with the fibres. It is also possible that the ozone consumption is excessive relative to the bleaching level, the reason being poor mixing of ozone with fibre suspension.

It has been determined in the tests performed that a characterizing feature of the mixers in accordance with the prior art is that the inlet pressure of the fibre suspension in the mixers, or more generally the pressure effect caused by the inlet opening, whether positive or negative, affects the mixing process. It has also been found that the pressure effect of the outlet opening for the fibre suspension also affects the mixing process. Further it has been found that the pressure variations caused by the inlet opening of fibre suspension affect as far as to the outlet opening and the pressure variations of the outlet opening affect to the inlet opening. The result thereof is that a portion of the gas flows very rapidly through the mixer. At its worst, it may be assumed that the mixer has a channel through which a portion of the gas flows almost without any obstructions. Accordingly, a portion of the gas will remain longer in the mixer. This results in an uneven dosing of gas to different parts of the fibre suspension, which again leads to an inhomogeneous pulp quality. The reason for the above described phenomenon is that the fluidizing apparatus arranged in the mixer is not alone sufficient to prevent the pressure variations through the apparatus.

The following introduces the most significant features of mixing gaseous ozone.

Ozone is the most rapidly reacting bleaching chemicals used to bleach pulp. Moreover, ozone is

the least selective, reacting with all reactive substances it encounters, even with substances it should not affect. It may be claimed that ozone cannot be compared with any other bleaching chemicals for said reasons. Due to the above mentioned features of the ozone it must be led to contact with each fibre in a mixture fluidized almost at a fibre level. One cannot rely on diffusion, as with other bleaching chemicals, in which it is sufficient that the chemical is brought to a short distance from a fibre floc of a reasonable size, from where it finds its way to the fibres.

Ozone may be industrially manufactured only in relatively dilute mixtures. In other words, only about 5 - 14 % of the gas to be supplied to the bleaching is ozone, the rest being a so called "carrier gas", which is usually oxygen or nitrogen, although also other inert gases, or at least inert compared with ozone, may be used. Thus, although relatively small ozone amounts are sufficient for bleaching a carrier gas must be supplied and mixed with ozone which is about 7-20 times the amount of the ozone.

The purpose of the present invention is to eliminate the disadvantages characteristic of the above mentioned apparatuses and methods in accordance with the prior art with the method and apparatus in accordance with the present invention, the characteristic features of which become apparent in the attached claims.

The method and apparatus in accordance with the present invention are described more in detail below, by way of example, with reference to the accompanying drawings, in which

Fig. 1 schematically illustrates an apparatus according to a preferred embodiment of the present invention;

Fig. 2 schematically illustrates an apparatus according to a second embodiment of the present invention;

Fig. 3 schematically illustrates an apparatus according to a third embodiment of the present invention;

Fig. 4 schematically illustrates an apparatus according to a fourth embodiment of the present invention;

Fig. 5 schematically illustrates an apparatus according to a fifth embodiment of the present invention;

Fig. 6 schematically illustrates an apparatus according to a sixth embodiment of the present invention;

Fig. 7 schematically illustrates an apparatus according to a seventh embodiment of the present invention;

Fig. 8 schematically illustrates an apparatus according to an eighth embodiment of the present invention;

Fig. 9 schematically illustrates an apparatus according to a ninth embodiment of the present invention;

Fig. 10 schematically illustrates, how gas accumulates on the trailing surface of an element moving in a gas-containing medium;

Fig. 11 schematically illustrates some cross-sectional alternatives for the arm of the blade to be used with the apparatus according to the invention;

Fig. 12 schematically illustrates some preferred symmetric cross-sectional alternatives for the blade to be used in an apparatus according to the invention;

Fig. 13 schematically illustrates some preferred asymmetric cross-sectional alternatives for the blade to be used in an apparatus according to the invention;

Figs. 14a-14c schematically illustrate the operation of the blade according to two embodiments of the invention;

Fig. 15 schematically illustrate the change in the power consumption due to the gas content in the pulp between an apparatus according to the present invention and an apparatus according to the prior art as a function of the rotational velocity of the apparatus; and

Figs. 16a and 16b schematically illustrate two process embodiments applying the apparatus according to the present invention.

Fig. 1 illustrates a mixer in accordance with a preferred embodiment of the invention, comprising an elongated mainly cylindrical mixer casing 10, two ends 12 and 14, conduits arranged in the casing for the incoming fibre suspension 16, for the outflowing fibre suspension 18 and for the gas/gas mixture to be mixed, more generally chemical, 20 and a rotor 22 rotatably arranged inside the casing 10 through the end 14. Rotor 22 comprises blades 34, 50 and mixing members 42 mounted in a suitable manner, preferably by means of arms 35, 51, to a shaft 24 or a hub arranged thereto. The shaft 24 of the rotor 22 is connected to conventional drive means (not shown).

The fibre suspension to be treated in the embodiment of Fig. 1 is supplied either radially or tangentially to a first mixing chamber 28, a so called premixing space or zone, through an opening 26 in the wall of the casing and a conduit 16 arranged in the mixing casing 10, to which chamber 28 also the gas to be mixed is brought in accordance with the embodiment of the drawing through a conduit 20 at the end 12 of mixing casing 10. Said gas feed conduit may also b arranged in the wall 30 of the casing (shown by reference numbers 120 and 130, for example, in Fig. 2), to the inlet conduit 16 for fibre suspension, or to the feed pipe for pulp flowing further up-

stream of the mixer (not shown). The only thing that must be taken into account is that gas is not supplied at such an early point to th pulp that a substantial portion of the gas could be consumed before its efficient mixing with the pulp, whereby there would also naturally be a risk that a portion of the fibre suspension could be over-exposed to ozone, in other words, the fibres could deteriorate.

The tip 32 of the rotor 22 preferably extends to a certain extent to a premixing space 28, in which the blades 34 arranged at the tip 32 generate an intense fluidisation of the fibre suspension, by means of which the large fibre flocs are broken and the supplied gas is evenly distributed within the whole premixing space 28 to the spaces between the small flocs. The wall of the premixing space 28 is preferably provided with ribs 36, by means of which the excessive rotation of the fibre suspension with the blades 34 of the rotor 22 is prevented. Most preferably the ribs extend throughout the whole length of the apparatus, possibly only altering their height in the different zones of the mixer. It is possible to add stationary mixing members 38 to the end 12 of the casing 10, the only purpose of which members is to add the turbulence to the pulp in the premixing space 28 and to prevent the excessive rotation of the pulp with the rotor 22. The mixing members 38 of the end 12 are preferably located radially inside the blades 34 of the rotor within a distance thereof. Both the blades 34 of the rotor and the ribs 36 at the wall of the casing are preferably substantially axial, but also fluidizing members having some other direction are possible. If required, the blades 34 of the rotor 22 may be made to feed some fibre suspension to the next zone. What is more important than the direction of the ribs 36 and the blades 34 is the distance between the blades 34 and the ribs 36 and the other dimensions thereof, by means of which the fluidization level of the premixing space is adjusted appropriate for the mixing. Features affecting the required fluidization level are, for example, the amount of fibre suspension to be treated (e.g., tons/hour), the consistency of fibre suspension, the amount of gas to be mixed, the origin of the fibres. Since the above mentioned factors provide various combinations, no generally applied dimensions or dimensioning principles are given.

The tip portion 32 of the rotor 22 is, for example, conical so that when the surface of the rotor 22 turns the pulp is directed to a fluidization zone, or a so called "homogenization zone" 40. The mixing in zone 40 is more intense than the previous one, in which also the flow velocity of the fibre suspension is at its largest due to a smaller cross-sectional flow area. In said zone 40 the mixture of the fibre suspension and gas is fluidized so efficiently that practically speaking all fibre flocs in the suspension are broken into small microflocs, containing only a few fibres. This allows the gas to be distributed evenly throughout the whol mixtur . In this zone 40, having a very strong turbulence, gas is mix d so well on the surface of the micro flocs that the gas consumption as a function of brightness may be minimized, and at the same time, that all the micro flocs and the fibres therein become equally treated.

The extremely intense fluidization in the homogenization space 40 is brought about by means of cogs 44 arranged to the wall 30 of the casing 10 and preferably radial pins 42 on the surface of the rotor 22. As for the shape of the so called pins 42, they may be round and radial, but also members having rectangular or polygonal cross-section or even of pyramid shape may as well be used. Both the pins and the cogs may have a similar shape. Fig. 1 illustrates two substantially circumferential rows of pins 42 on the surface of the rotor and one cogged ring 44 located therebetween on the wall 30 of the casing 10. Of course, the number of both the pins 42 and the cogged rings may deviate from the above description. Preferably, the pins 42 and the adjacent cogged rings 44 are located in such a way that they are interlacing. The same applies also to the cogs 44, if there are more than the illustrated one cogged ring. Preferably, each of the cogged rings is formed of a continuous ring 46, arranged on the wall of the casing, and of cogs 44 extending inwards towards the axis. Thus, the flow is apparently throttled at the cogged ring 44. The number of both the cogs 44 and the pins 42 in each ring varies according to the size of the apparatus from 2 to 15. Another method to throttle the flow in the homogenization zone is, of course, to arrange the pin ring of the rotor to begin from an annular flange arranged on the rotor surface to radially extend towards the wall of the mixer casing.

By utilizing the throttling of the flow as described above, it is possible to prevent the pressure variations of the inlet and outlet from effecting each other. By forcing the fibre suspension flow through a flow channel small enough it is ensured that the mixing process in the homogenization zone is optimal, whereby the gas is distributed evenly to the whole fibre suspension. The operation of the throttling illustrated in Fig. 1 is as follows. When striving towards the maximization of the shear forces relative to the volume, a large number of pins and cogs are arranged on the wall of the rotor and the casing in the embodiment in accordance with Fig. 1. In so doing, a pr ferred three-dimensional turbulence field is created. In practice, this means that at the Same time as the pins of the rotor tend to rotate the fibre suspension circumferentially, the first pins in the flow direction of the

fibre suspension "throw" the fibre suspension against the wall and the counter rib 36, from where in order to axially flow forwards the flow must, to avoid the throttling, move towards the axis, from where after passing the throttling the fibre suspension is again thrown, due to a second set of pins against the wall and counter rib 52 of the casing. If there is a second cogged ring after the first one, this forces the flow against the centrifugal force towards the shaft of the rotor. Thus the fibre suspension is forced by pins and counter ribs to radial and axial movement as well as circumferential movement, whereby, due to the pulse-like force effects caused by said members, a three-dimensional turbulence field is generated.

The homogenization zone 40 is followed by a zone of weaker turbulence, a so called "maintenance zone" 48, which is also called a "reaction zone" or "discharge zone". The diameter of the rotor 22 is in the embodiment of Fig. 1, substantially smaller than at the homogenization zone 40 and the rotor 22 is provided with blades 50. The wall 30 of the casing 10 at the maintenance zone 48 is preferably provided with ribs 52, which are, however, lower than the corresponding ribs 36 of the premixing zone 28. As may be deduced from the name of the zone, the purpose of the zone 48 is to maintain a sufficient turbulence or fluidization level in the fibre suspension so that the gas does not separate, but it may continue the reaction, which was made possible by the even distribution of gas in the homogenization zone 40 almost to the fibre level. It is also a purpose in the maintenance zone 48 to accelerate the rotational velocity of the mixture formed by the fibre suspension and gas so that the mixture may be removed from the apparatus preferably through a tangential conduit 18. However, the rotational velocity must be maintained at a level, which does not give the gas a possibility to separate around the rotor 22. Such separation tendency of the gas may still be made more difficult by arranging stationary blades 54 extending preferably axially to the maintenance zone between the blades 50 and the surface of the rotor 22. When the fibre suspension has received an appropriate kinetic velocity by the blades 50 and when the discharge conduit 18 is correctly designed, the fibre suspension - gas mixture is discharged from the mixer in such a way that gas does not separate, but the bleaching chemical in the residual gas may without any hindrance continue the reaction in the exhaust pipe and/or in the actual bleaching reactor following it, if such is necessary. Such a separate bleaching reactor is according to the modern technology not necessary when using ozone as bleaching chemical. In some cases, however, a considerable extension of the reaction zone is required, which results in additional consumption of energy, if a sufficient turbulence level is desired to be maintained so as to eliminate the separation of gas.

It is a characterizing feature of the whole construction described above that the basis of the construction has been to minimize the areas liable for gas separation, and if it has been necessary to leave such places in the apparatus, to minimize the effect thereof by preventing the flow of the gas in the axial direction of the apparatus. In other words, the channelling tendency of the separated gas, i.e. the flow along a path from the gas inlet or separation point to the discharge of the pulp has been attempted to be eliminated, or at least minimized. Examples of the construction alternatives aiming at said purpose illustrated in Fig. 1 are, for example, blades 34 and 50, ring 46 and an annular flange mentioned in connection with pins 42.

It is a characterizing feature of said blades 34 and 50 that they are not mounted to the rotor throughout the whole length thereof, but by means of arms 35, 51. The purpose is to prevent the formation of a large gas bubble behind the trailing side of the blade and/or arm of the blade. In the embodiment of Fig. 1, only a very small gas bubble will form behind the arm of the blade. Further, due to the free space between the blades 34, 50 and the hub or the rotor body of the rotor 22, the pulp flow will rotate the blade so that hardly any gas will accumulate behind the blades 34, 50. In the embodiments described later on, said accumulation tendency of the gas is tended to be decreased. The ring 46 again prevents the gas accumulated behind the counter ribs 36 from flowing along the rib towards the outlet opening for pulp. The ring 46 forces the gas towards the rotor 22, whereby the intense turbulence generated by the pins 42 breaks the gas bubbles and mixes them evenly with the pulp. Similarly, the annular flange possibly arranged with the pins 42 on the side of the rotor 22 prevents the movement of the gas bubble possibly generated around the rotor axially towards the pulp discharge by forcing them radially outwards, in which an intense turbulence mixes the gas evenly with the pulp.

Yet another feature disturbing the gas separation tendency worth mentioning is the construction of the rotor itself or more accurately the existence of the rotor body. When transferring a fibre suspension in a fluidizing apparatus provided with a rotatable rotor in the axial direction from the inlet opening towards the outlet opening, the pulp tends to rotate with the rotor along the rim of the apparatus regardless of, whether stationary ribs have been arranged to the rim or not. The rotational movement of the pulp again tends to separate gas to the centre of the flow, whereby a natural way of preventing the accumulation of gas is to arrange the

construction of the rotor such that it fills the space, to which the gas could otherwise separate. So in the illustrat d embodiments both in the homogenization zone and in the maintenance zone the rotor body is relatively thick and leaves only a limited space between itself and the wall of the casing. In the premixing space the centre of the rotor is practically speaking open, since in most cases the rotational movement of the pulp has not yet had time to accelerate to such an extent that the gas would begin to separate. On the other hand, large amounts of gas are fed to the premixing space, whereby the gas is in the form of large bubbles without it being evenly distributed in the fibre suspension. Thus the arrangement of a rotor body extending from the inlet end throughout the whole apparatus would not be justified.

Fig. 2 illustrates a mixer in accordance with a second embodiment of the invention. In an embodiment in accordance with the drawing the diameter of the rotor 122 of the mixer is not decreased after the homogenization zone 40, but it is increased by means of an intermediary part 156 so that at the outlet opening 18 the diameter of the rotor 122 is relatively large, and the surface of which rotor 122 is provided with ribs 158 in order to maintain the turbulence level high enough to maintain the gas evenly distributed throughout the whole suspension. The embodiment of the drawing illustrates also a second cogged ring 144 located at the conical intermediary part 156 and the cogs of which do not have to extend so far in the homogenization space 40. Further, in the embodiment of the figure the blades 134 at the tip 132 have a form slightly deviating from the embodiment of Fig. 1. In other words, the extensions of the blades extending towards the homogenization zone 40 from the mounting point of the blades 134 have been left out. Of course, different variations illustrated in Fig. 2 may be applied separately without any need to use them all in a manner illustrated in the figure. Fig. 2 also illustrates that an inlet conduit 120 for gas may be in the wall 130 of the mixer casing and that the inlet opening for pulp may also be in an angle position relative to the outlet opening 18 (90° angle shown).

A combination of embodiments in Figs 1 and 2 worth mentioning is an embodiment, in which the rotor is practically speaking similar to that of Fig. 1 and the casing partially similar to that of Fig. 2. Thus the wall of the casing has two cogged rings, which operate as already mentioned above, in other words, one of the cogged rings, 144, directs axial flow towards the rotor, which results in a situation in which the incoming flow passes along the surface of the rotor in the reaction zone until the end of the apparatus, rises there due to the centrifugal force to the rim of the casing and is only there able to be discharged from the apparatus. By this operation model it is ensured that, practically speaking, no part of the flow is able to flow directly from the premixing zone to the pulp discharge, in other words the channelling of the pulp is prevented, but the pulp must circulate one cycle in the reaction zone. This is also used for increasing the retention time of pulp in the apparatus so that there will be enough time to carry out the ozone bleaching reaction practically speaking completely in the apparatus itself.

Fig. 3 illustrates a mixer in accordance with a third embodiment of the invention, which may be of the construction either similar to Fig. 1 or Fig. 2 (shown in the drawing) or to a different combination of the variations thereof except that the inlet opening 226 for fibre suspension is, in the embodiment of Fig. 3, axial and the inlet conduit 220 for gas is (shown in the drawing) radial. In other words, the inlet opening 226 for fibre suspension is preferably located in the end 12 of the casing and the inlet conduit 220 for gas preferably to the wall 30 of the casing 10. An alternative for the inlet opening 226 shown in the drawing worth mentioning is an embodiment in which the end of the apparatus corresponds to Fig. 1 so that the pulp is supplied from the inside of the stationary mixing members 38 of Fig. 1 axially to the apparatus.

Fig. 4 illustrates yet an alternative to the tip portion 32 of the rotor illustrated in the previous drawings, which tip portion may be according to the figure provided with mixer blades 360 extending almost or even to the axial line in addition to the blades 334 parallel to the axis of the previous embodiments, but within a distance from the axis. The drawing also illustrates a possibility that the diameter of the rotor 22 may be practically speaking constant for the whole length of the rotor 22, in other words constant in the homogenization zone 40 and maintenance zone 48. It is significant for the embodiment of the figure that the width of the blades 334 and 360 is relatively insignificant compared of their radial dimension, whereby no significant gas accumulation will generate behind them. On the other hand, the form of the blades also enables the circulation of the pulp flow around the blades. It has also been noted that, although gas could separate in theory to the inside of the blades 360 to the open centre of the rotor, it does not happen in practice since the centrifugal field required by the separation of gas does not have time to generate.

Fig. 5 illustrates a construction alternative typical of Fig. 1, in which the edges of the blades 134 and 150 of the rotor are provided with either triangular cuts 168 or rectangular or otherwise appropriately shaped cuts 166, the purpose of which is further to decrease the size of the gas bubble

tending to accumulate behind the blades. The cuts 166 and 168 may be located either only to the outer edge of the blades 134 and 150 or also to the ends and inner edge of the blades. The cuts 166 and 168 generate microturbulence in the surrounding space, which tends to break the gas bubble generated behind the blade 134, 150. Since it has been found out in the performed experiments that the optimization of the clearances between the rotor and the counter members thereof is very important, the counter ribs 136 and 152 on the wall of the casing are preferably provided with protrusions 178 and 176 facing the cuts in the blades 134 and 150 of the rotor, said protrusions being shaped like the cuts of the rotor blades. In this way, the aim that the rotor blade must not rotate the pulp, but on the other hand the differences in the velocity must be generated as efficiently as possible, is achieved. It is, of course, possible to arrange protrusions to the blades and respective recesses to the counter ribs. The drawing also illustrates a method, by means of which the accumulation of gas is prevented and/or minimized behind the counter rib 136 or some other stationarily mounted rib. The bottom part of the rib 136, in other words the mounting line between the wall and the rib of the casing is provided with perforations, openings or gaps 180, through which the pulp jet is allowed to be discharged behind the rib thus reducing the size of the gas bubble. More generally, it is sufficient to provide the rib itself with some kind of flow opening, through which the fibre suspension is allowed to flow to the "back side" of the rib, regardless of whether said opening is limited either completely to the rib material or partially to the wall of the casing. This embodiment is in fact operationally identical with the embodiment leaving a gap between the hub of the rotor and the rotor blades.

Fig. 6 illustrates a blade structure in connection with the apparatus similar to Fig. 4, in which the blades 334 and 360 in the premixing zone of the rotor are provided with openings 362 and 364, of which the first-mentioned are located at the connecting point between the rotor and the blades and the latter farther out onthe blades. The purpose of the openings is to prevent the accumulation of a gas bubble behind the blades. The drawing also illustrates a blade 258, which is in a way similar to the blade of Fig. 1 in the sense that there is a gap between the main part of blade 258 and the rotor, through which the fibre suspension is allowed to flow through the blade and the rotor and thus prevent the generation of a large gas bubble, although in this particular embodiment illustrated by this drawing the preferably axial main part 258 of the blade is attached from the ends by means of some kind of arms to the hub of the rotor. The pulp flow being discharged through the openings 362 and 364 decreases the gas bubble, which otherwise accumulates behind the blad s, to an insignificant size according to a theory. However, the dimensioning of the size of the openings is important, since on the other hand the purpose is to generate a flow circulating around the blade. A pulp jet being discharged through an opening incorrectly dimensioned may completely prevent the generation of such a desired circulating flow.

Fig. 7 illustrates another rotor arrangement, in which the blades 234 and 250 are not axial, but they form an angle with the axis. The drawing also illustrates with a broken line, how an opening 364 in the blade 234 may extend almost throughout the whole length of the blade from the bottom to the tip of the blade.

Fig. 8 illustrates an embodiment clearly different from the embodiments illustrated in the previous drawings. The arrangement in accordance with this embodiment illustrates firstly that a mixer in accordance with the present invention, in fact also any mixer in accordance with any of the previous embodiments, may be assembled vertically, for example, so that the drive means is located below the mixer. A second feature in the embodiment of Fig. 8 is that pulp is supplied either radially or tangentially to the apparatus at the end 14 of the mixer casing 430, in other words to a point where the rotor body closes the centre of the rotor 422. In the embodiment illustrated by the figure the pulp is supplied together with the chemical to be mixed through a conduit 416. Further, unlike the previous embodiments, pulp is discharged from the apparatus axially mainly according to the method illustrated in WO patent application 93/07961. Briefly, the pulp, to which the gas is evenly distributed in the homogenization zone 440, is discharged evenly diminishing turbulence throughout the whole suspension to an extending axial discharge channel 418. The widening of the cross-sectional flow area of the discharge channel may be made in principle in two ways, either by letting the flow channel widen by itself, for example, either conically or preferably parabolically or this can also be carried out by a combination of the above-mentioned methods, as shown in the drawing. Preferably, the discharge channel 418 is further connected to a widening part 470 of the flow piping or to a reaction vessel specially designed for the purpose. The purpose is to dampen the turbulence in the mixture of fibre suspension and gas so that the gas does not separate to any part of the flow, but remains homogeneously distributed in a laminar plug flow.

As for the details of other subunits of the apparatus, they are described in the previous embodiments, so it is clear that a combination appro-

priate for the purpose may be constructed also for this embodiment.

Fig. 9 introduces an arrangement in accordance with a preferred embodiment of the present invention, i.e. a distributing mixer. Based on the arrangement of Fig. 6 the reaction zone 548 of the mixer casing 530 is provided with four equally-spaced discharge conduits 518, although the number thereof may vary. Several discharge conduits 518 are required, for example, when pulp is desired to be passed to targets spaced apart, or when it is desired to feed the pulp, for example, through four inlet openings located in the bottom of the oxygen or peroxide bleaching tower into the tower in order to prevent channelling in the bleaching tower.

Fig. 10 schematically illustrates how gas attempts to accumulate in the flow forming a "tail" adjacent the trailing surface of a movable object, regardless of whether it is a rotatable blade or an arm of a blade to be attached to a rotor. The arrow refers to the direction of movement of said object in the flow.

Fig. 11 illustrates different cross-sectional alternatives for an arm of a blade. The arrow beneath the cross-sectional views shows the direction of movement of an arm of a blade. The left arm has the cross-section of either a square or at least of the shape of a rectangular prism. It causes a considerably large gas accumulation shown in Fig. 10 to the trailing surface, but the illustrated arm is most inexpensive to manufacture. The middle arm of the illustrated arms is substantially round in the cross-section, whereby the size of the gas bubble accumulating behind the arm is already considerably smaller than the previous alternative. The cross-section of the rightmost arm of the blade among the illustrated is drop-like, which allows hardly any gas to separate behind it, but it passes the flow streamlined. When mounting the blade by using such a drop-like arm, it is possible to turn the arm relative to its longitudinal axis so that the axis of symmetry thereof will be completely parallel to the resultant of the velocities of the blade and the flowing pulp.

Fig. 12 illustrates a number of possible cross-sectional shapes of a blade, the axis of symmetry of which is substantially parallel to the direction of movement of the blade or to the tangent thereof. The leftmost cross-section illustrates either a square or at least a rectangular cross-section of the blade. The second cross-section on the left illustrates a combination of a generally curved surface and planar surface, which may also be extended to a combination of two curved surfaces. This is, however, preferably a combination of a cylindrical surface and a planar surface. The cross-section in the middle illustrates a blade having a shape of an isosceles triangle. The second on the right illustrates a blade having the sides of a triangle "blown outwards", whereby the cross-section of the blad has a bullet-like appearance. It is also possible to manufacture the sides S inwardly bent, in other words, concave, but this would increase the size of a gas bubble to some extent compared with the illustrated embodiment. The rightmost cross-section illustrated is elliptic, although this description applies a round cross-section which is a special form of an ellipsis.

At this stage it should be remembered that Fig. 11 illustrates cross-sectional shapes of the arm of the blade that are used for minimizing the size of the gas bubble, the corresponding cross-sectional forms are not used for the blade, because the blade would not be able to generate turbulence sufficient for mixing. Thus with a solid blade a compromise must always be found between the size of the gas bubble and the mixing efficiency. A rule of thumb is that both the size of the gas bubble and the mixing efficiency will increase in the same proportion, in other words, both factors are directly proportional with each other. Fig. 12 contains the solid arrow, which illustrates the direction of movement of the blade according to the present knowledge, but the broken line arrow illustrates a possible direction of movement of the blade, when taking all different applications and the compromising factors into consideration.

Fig. 13 illustrates a number of cross-sectional alternatives for the blade, which are neither symmetric nor are their axis of symmetry not parallel to the direction of movement of the blade nor to the tangent thereof. The leftmost is a blade of triangular cross-section or altered by providing it with slightly curved side surfaces C, directing the gas bubble behind it in the embodiment of the drawing to a certain extent below the longitudinal axis of the blade. The second on the left illustrates a blade having a semi-circular cross-section, presenting a combination of a plane and a curved surface or of two curved surfaces. The blade of the -drawing leaves a considerably small gas trace behind. The second on the right illustrates a blade having a rectangular or square cross-section, which leaves a gas bubble, which does not significantly differ from the gas bubble of a corresponding object arranged symmetrically. The rightmost blade has a triangular cross-section and is positioned at such an angle that the gas trace accumulated behind the blade flows to some extent aside relative to the blade itself. If it is, for example, imagined that the centre of the rotor is located in Fig. 13 beneath the blad , the gas trace surface extends beyond the tip of the rotating blade having the right-most cross-section of Fig. 13. When taking into consideration the counter ribs operating together with the rotor

blades illustrated in all Figs. 1-7. a counter rib. e.g. 36,52 strikes most of the gas bubble and by breaking th bubble mixes th gas efficiently with the pulp. This kind of blades are preferably used in the premixing zone. If corresponding blades were used in the so called reaction zone, there would be a risk that the gas bubble rotating behind the blade would become loose just at the discharge opening for pulp and be discharged with pulp. It is preferable to use a cross-section in accordance with the leftmost embodiment in Fig. 13 in the blade of the reaction chamber, whereby the blade itself keeps the gas bubble as far from the discharge opening for pulp as possible.

Fig. 14 schematically illustrates the effect of the cuttings at the edge of the blade, openings or like in the blade on the gas bubble behind the blade. Figs. 14a and 14b illustrate a part of the blade 150 already illustrated with Fig. 5, having an edge on the mixer casing side cuttings 166 machined within a certain distance. Behind the blade 150 there is formed a gas trace the size of which depends on the cross-sectional form of the blade, which is practically speaking equal in breadth and equally thick throughout the whole length of the blade. However, the cuttings 166 machined at the edge of the blade 150 allow the pulp to be discharged therethrough, whereby the pulp being discharged through the cutting 166 behind the blade tends to deflect the gas bubble. This results in a backwards spreading pulp jet. The final result is that the size of the gas bubble has been reduced considerably more than what can be expected from the ratio of the size of the cuttings 166 to the unbroken surface of the blade. The size of the gas bubble is reduced in both the circumferential direction (Fig. 14a) and in the radial direction (Fig. 14b), the pulp jet widens in a similar manner.

Fig. 14c illustrates yet another alternative arrangement, in which the edges of the blade 334 (shown in Fig. 6) have not been notched or cut (although they could quite as well be serrated, but the blade is for simplicity and clarity shown unnotched) and an opening 364 has been made to the middle part of the blade, through which opening the pulp is allowed to be discharged behind the blade 334. The pulp jet creates, in the similar way as in Fig. 14a, a restriction or confinement of the gas bubble, limiting the bubble to a size smaller than would be expected. However, when building a blade in this way, it must be taken into consideration that a strong pulp jet being discharged through the blade may prevent the flow desired around the blade 334. It may be wiser to limit the opening 364 in such a way that the flow begins to circulate through opening 364 according to the arrows shown in Fig. 14c, while minimizing the impact upon the desired gross flow of pulp around blade 334.

At this stage it must b noted that it is known in the art that power consumption is an indication of mixing efficiency. In other words, the better the mixer creates turbulence in the pulp, the higher is the power consumption. However, the benefits from mixing efficiency far outweigh the increased power consumption.

Example

In the performed experiments, a modified version of a known chemical mixer for mixing large amounts of gas was compared with the mixer in accordance with the present invention. It was discovered that the easiest way to compare, said mixers was to monitor the change in energy required for mixing as a function of the gas amount in the gas-fibre suspension. In the experiments performed and in theoretical calculations, it has been observed that in an optimal mixing the mixing efficiency should reduce in the same ratio as the gas is added to the suspension. In other words, a 20 % gas addition should reduce the mixing efficiency only by about 20 %.

Fig. 15 illustrates the decrease in the power consumption of a modified prior art chemical mixer as a function of the gas content and the rotational velocity of the rotor. In the figure, the efficiency required for mixing the pulp having 20 % gas has been compared with the efficiency required for mixing mere gas-free pulp. In other words, the 100 % line shows the efficiency required for mixing mere pulp and the lower curves the efficiency required for mixing pulp containing 20 % gas compared with the efficiency required for mixing gas-free pulp. It may be seen that, for example, the power consumption of the mixer in accordance with the prior art within the rotational velocity range used in the experiments varied with gaseous pulp between about 40 % and 23 % from the efficiency required for mixing gaseous pulp. The power consumption in a mixer in accordance with the present invention reduced only 18 - 22 %, whereas the reduction of power consumption of a mixer in accordance with prior art was 60 - 77 %.

It may be stated that the mixture of fibre suspension and gas is mixed by efficiency P_{tod}, the amount of which is calculated as follows:

$$P_{tod} = 0.9...1.0^{*}(1-p_g/100)^{*}P_{teor},$$

preferably

$$P_{tod} = 0.95...1.0^{*}(1-P_g/100)^{*}P_{teor},$$ in which

P_g = amount of gas in suspension as vol-%;

and

P_{teor} = efficiency required for mixing of gas-free pulp.

One explanation for the great reduction in the power consumption in the mixer of the prior art is that a large amount of the mixing elements of the mixer rotates in a "gas bubble", whereby the power requirement diminishes almost to non-existent. In other words, a mixer in accordance with the prior art has not been able to mix gas hardly at all, but the gas has been able to separate around the mixer members. Respectively, the small decrease in power consumption of the mixer in accordance with the present invention means that the power demand decreases only to the extent which the increase of gas diminishes the consistency of the pulp, which leads to the fact that the gas is equally distributed to the fibre suspension.

Figs. 16a and 16b illustrate two more special applications of the mixer in accordance with the present invention. Fig. 16a illustrates a part of an ozone bleaching process in which the pulp raised to a relatively low pressure (4 - 8 bar) by a pump P1 is led to a mixer S1, to which ozone gas together with the carrier gas is led either separately or together with pulp at a pressure higher than the pulp pressure (5 - 10 bar). The pulp is discharged from mixer S1 along a channel to a pump P2 located substantially in a close proximity to the mixer, by means of which pump P2 the pressure is raised, for example, to 10 to 20 bar, whereby the gas volume in the pulp decreases and according to the our experiments the bleaching result is improved. By the pump P2 the pulp may be led either to a reactor specially designed for the purpose or, for example, along a conventional pipe line to the next treatment stage.

Fig. 16b illustrates a process in accordance with a second embodiment of the invention. It is a characterizing feature of the process that the pressurization of the pulp by the pump P1 to a low pressure and the mixing of ozone by the mixer S1 to the pulp takes place in the same way as in Fig. 16a, but the mixer S1 is not followed by a pump as a pressure-increasing apparatus as in Fig. 16a, but a mixer SP1, by which the pressure of the pulp may be raised to 10 - 20 bar. The advantage in the use of the second mixer SP1 is that if the gas is not completely equally distributed in the first mixer S1 with the pulp, this may be ensured by a pressure-increasing mixer SP1 located immediately after the first mixer S1.

Of course a third alternative is to use a pressure-increasing mixer already in the first mixing stage, whereby the process cannot be considered to be as efficient as the process in accordance with Fig. 16b, but, however, sufficient for most purposes.

Yet, a construction utilizing different mixing alternatives in accordance with the present invention worth mentioning is a pump pumping gas-containing material. The problem with all known centrifugal pumps is that when the material to be pumped is gas-containing the gas tends to separate in front of the impeller, because the impeller makes the material flow in the suction channel to turn into spiral flow, whereby the generating centrifugal force facilitates the separation of gas to the centre of the flow. Previously this problem has been tended to be solved by drawing the gas from the pump either through the openings arranged through the impeller or through a suction channel in a pipe led in front of the impeller. As a substantial part of our invention the different rotor/blade/counter rib arrangements for mixing gas and/or preventing the separation of gas arranged to the suction side of the centrifugal pump prevent the separation of gas. They are arranged to the suction side of a centrifugal pump in a similar way as the fluidizing rotor mounted to the shaft of a pump in front of an impeller as in the so called MC-pumps. Therefore the pump does not have to be provided with special gas discharge apparatuses, but significantly less expensive apparatuses preventing the separation of gas are sufficient. Thus all the features described both in the previous description and in the enclosed claims 9 through 39 may also be applied to a centrifugal pump, the suction channel of which corresponds to a mixer casing in the mixer construction illustrated above. In performed experiments even an apparatus designed to operate as a mixer is noted to increase pressure for at least 5 mH_2O, which suggests the gas treatment ability of the apparatus is fully under control, since the accumulation of the gas does not disturb the operation of the apparatus. In the mixer use the pressure-increasing feature is very advantageous, since, for example, in the dimensioning of an ozone bleaching plant the pressure loss in the mixer does not have to be taken into consideration, but it may even be considered to take care of at least a part of the work required for the transfer of pulp to the next treatment stage.

As may be seen from above, it has been possible to develop a chemical mixer operating considerably more efficiently than the apparatuses previously applied for the process. It may be used for mixing large amounts of gas to a medium consistency pulp without a risk of the separation of gas either in th middl of the mixing process or when having the suspension discharged from th mixer. Although each of the previously described drawings illustrate different constructions, all constructions are optional and may be combined, so it

is apparent that the constructions in the different drawings may be freely combined.

As becomes clear in the claims, the invention also contains such an embodiment, in which both the premixing zone and the maintenance zone illustrated in the drawings are removed. In other words the homogenization zone is considered to be able to take care of the whole mixing process. The negative aspect of the exclusive use thereof is the high amount of power required. For minimizing the power usage the zone preceding and following the homogenization zone have been proved advantageous and taken into use.

Reference signs in the claims are intended for better understanding and shall not limit the scope.

Claims

1. A method of mixing large amounts of gas into a medium consistency (8 to 25 %) fiber suspension by means of a mixer having a rotor provided with blades, a casing provided with an internal wall having ribs, an inlet and an outlet, said method comprising the following steps: a) passing said gas and fiber suspension to the mixer; b) mixing said gas in the fiber suspension in a fluidized state; and c) removing the thus obtained mixture from the mixer, **characterized** in that during step b) the gas-fiber suspension mixture is homogenized by fluidizing the mixture and at the same time throttling the flow through the mixer in such a way that the effect of the fluctuation in pressure of the inlet and the outlet of the mixer is minimized in the mixing process.

2. A method in accordance with claim 1, **characterized** in that step b) is divided into three sub-steps:

   b1) premixing, in which the fiber suspension is fluidized to floc level and the gas is evenly distributed throughout the whole suspension;

   b2) homogenization, in which the fiber suspension is fluidized to fiber or microfloc level and the gas is brought into contact with each fiber/microfloc; and

   b3) maintenance/reaction, in which the fluidization level is maintained high enough to prevent the generation of gas bubbles and the separation of gas.

3. A method in accordance with claim 2, **characterized** in that the rotational movement of fiber suspension caused by the rotor is decelerated during the whole substep b2).

4. A method in accordance with claim 2, **characterized** in that the rotational movement of the fiber suspension caused by the rotor is decelerated during all substeps b1), b2) and b3).

5. A method in accordance with claim 2, **characterized** in that in at least one of the substeps b1) - b3) mixing of gas is intensified and the separation of gas from the fiber suspension is made difficult by bringing the fiber suspension to a rotational movement around the blades of the rotor.

6. A method in accordance with claim 1, **characterized** in that said ribs have gaps (openings) (180) and a part of the fiber suspension flow is passed through said cutting(s), in order to make the separation of gas behind said rib more difficult.

7. A method in accordance with claim 2, **characterized** in that at least in one of the substeps b1) - b3) the separation of gas is made more difficult by having cuts 166, 168 in the surface of the rotor blades and/or the ribs of the mixer casing in such a way that no large dead space is created behind said blades and/or ribs, in which gas naturally tends to separate.

8. A method in accordance with claim 1, **characterized** in that the mixture of fiber suspension and gas is mixed at a power P_{tod}, the amount of which is calculated as follows:

   $P_{tod} = K^*(1-p_g/100)^*P_{teor}$,
   P_g = amount of gas in the suspension as a vol-%;
   P_{teor} = power required for mixing of gas-free pulp; and
   K = predetermined constant ranging from 0.9 to 1.0, preferably ranging from 0.95 to 1.0.

9. An apparatus for mixing large amounts of gas to a medium consistency fiber suspension, which apparatus comprises a mixer casing (30), the casing having two ends (12, 14), at least one suspension inlet conduit (16, 416) and at least one suspension outlet conduit (18, 518), and a rotor (22) rotatable in said casing and a shaft (24) attached to and driving said rotor, **characterized** in that the most intense mixing zone of th mixer casing (30, 430, 530) is provided with means (42, 44, 46, 144) for both throttling the flow through the mixer and homogenizing the gas-fiber suspension mixture.

10. An apparatus in accordance with claim 9, **characterized** in that said means comprises at least one throttling ring (46) mounted upon one of said rotor (22) or mixer casing (30, 430, 530) and mixing members (42) operating together therewith.

11. An apparatus in accordance with claim 9, **characterized** in that the casing (30, 430, 530) of the apparatus is axially divided into at least two of the following zones: premixing zone (28), homogenization zone (40) and maintenance, i.e. reaction zone (48).

12. An apparatus in accordance with claim 9, **characterized** in that the casing (30) of the apparatus is divided axially into three zones: premixing zone (28), homogenization zone (40) and maintenance, i.e. reaction zone (48, 548).

13. An apparatus in accordance with claim 11 or 12, **characterized** in that the premixing zone (28) is provided with means (34, 36, 38, 134, 168, 180, 234, 334, 360, 362, 364) for fluidizing said fiber suspension to floc level and for distributing said gas evenly throughout the whole premixing zone (28).

14. An apparatus in accordance with claim 11 or 12, **characterized** in that the homogenization zone (40, 440) is provided with means (42, 44, 46, 144) for fluidizing the gas-fiber suspension mixture generated in the premixing zone (28) to fiber or microfloc level and for passing said gas into contact with each fiber/microfloc.

15. An apparatus in accordance with claim 11 or 12, **characterized** in that the maintenance, i.e. reaction zone (48, 548) is provided with means (50, 52, 54, 150, 158, 166, 176, 250, 258) for maintaining the turbulence level of the homogeneous gas-fiber suspension mixture generated in the homogenization zone (40, 440) at a level high enough in order to prevent the generation of gas bubbles and to maintain the mixture homogeneous.

16. An apparatus in accordance with claim 13, 14 or 15, **characterized** in that said means include a rotor (22), at least part of which extends from one end (14) of the apparatus throughout the whole apparatus to close proximity of the other end (12).

17. An apparatus in accordance with claim 13, 14 or 15, **charact riz d** in that said means include mixing means (50, 150, 158, 166, 250, 258) arranged on the surface of the rotor (22).

18. An apparatus in accordance with claim 17, **characterized** in that said means include mixing means (52, 176) arranged on the inner surface of the mixer casing (30, 430, 530) operating together with mixing means (50, 150, 158) of the rotor (22).

19. An apparatus in accordance with claim 17, **characterized** in that said means include mixing means (54) arranged at least at one end (14) of the mixer casing (30, 430, 530) operating together with mixing means (50, 150) of the rotor (22).

20. An apparatus in accordance with claim 18 or 19, **characterized** in that said mixing means (52, 54, 176) are radially within a distance from said mixing means (50, 150, 158, 166, 250, 258) of said rotor (22).

21. An apparatus in accordance with claim 13, 14 or 15, **characterized** in that said means include ribs (36, 52, 136) on the wall of the mixer casing (30) and blades (34, 50, 134, 150, 158, 234, 250, 334) of the rotor (22) radially extending to a distance from said ribs (36, 52, 136).

22. An apparatus in accordance with claim 13, 14 or 15, **characterized** in that said means include pin-like members (42) arranged on the surface of the rotor (22) and mixing means (44, 46, 144) extending inwards from the wall of the mixer casing (30, 430, 530) and operating together with said members (42).

23. An apparatus in accordance with claim 22, **characterized** in that pin-like members (42) are arranged to protrude from an annular member arranged on the surface of the rotor (22).

24. An apparatus in accordance with claim 18, **characterized** in that said mixing means (44, 144) are arranged to protrude from an annular member (46) attached to the interior of the wall of the mixer casing (30, 430, 530).

25. An apparatus in accordance with claim 24, **characterized** in that said annular members (46) form said means for throttling the flow.

26. An apparatus in accordance with claim 24, **characteriz d** in that said mixing means (44, 144) are cogs at the inner edge of said ring (46).

27. An apparatus in accordance with claims 18 and 22, **characterlz d** in that both said pin-like m mbers (42) and said mixing members (44, 144) extending in circumferential rows on the internal wall of said casing (30, 430, 530).

28. An apparatus in accordance with claim 27, **characterized** in that said pin-like members (42) and said mixing members (44, 144) extending from the wall of said casing are within an axial distance from each other.

29. An apparatus in accordance with claim 11 or 12, **characterized** in that cross-sectional flow area in the mixer is at the minimum between the mixer casing (30, 430, 530) and the rotor (22) in the homogenization zone (40, 440).

30. An apparatus in accordance with claim 22, **characterized** in that the number of said pin-like mixing members (42) for each pin ring ranges from 2 to 15.

31. An apparatus in accordance with claim 9, **characterized** in that the outlet conduit (418) for gas-fiber suspension mixture is at one end (412) of the mixer casing (430).

32. An apparatus in accordance with claim 21, **characterized** in that an opening enabling the flow has been arranged between the blade (50, 150, 158, 250, 258) of the rotor (22) and the rotor (22), in other words the blade (50, 150, 158, 250, 258) is located within a distance from the rotor (22).

33. An apparatus in accordance with claim 21, **characterized** in that said ribs (136) are provided with flow openings, preferably with openings (180) between the rib (136) and the wall of the mixer casing.

34. An apparatus in accordance with claim 21, **characterized** in that said ribs (136, 152) are provided with protrusions (178, 176) and said blades (134, 150) with recesses (168, 166) operating together with at least said protrusions (178, 176).

35. An apparatus in accordance with claim 21, **characterized** in that said blades are provided with protrusions and said ribs with recesses operating together with said protrusions.

36. An apparatus in accordance with claim 21, **characterized** in that said blades (234, 334, 360) are provided with openings (362, 364) in order to guide the fiber suspension flow to pass through the blade to mix the gas tending to accumulat behind the blade back to the fib r suspension.

37. An apparatus in accordance with claim 31, **characterized** in that the cross-sectional flow area of the outlet conduit (418) widens in the flow direction.

38. An apparatus in accordance with claim 37, **characterized** in that the tip portion (432) of the rotor (422) narrows in the flow direction.

39. An apparatus in accordance with claim 9, **characterized** in that the mixer casing (530) is provided with a number of discharge conduits (518).

40. Centrifugal pump for pumping gaseous liquids, which pump comprises a rotor located in the suction channel and an impeller, **characterized** in that means (42, 44, 46, 144) for throttling the flow and homogenizing the gas-fiber suspension mixture are provided in the most intense mixing zone of the suction channel (30, 430, 530) of said pump.

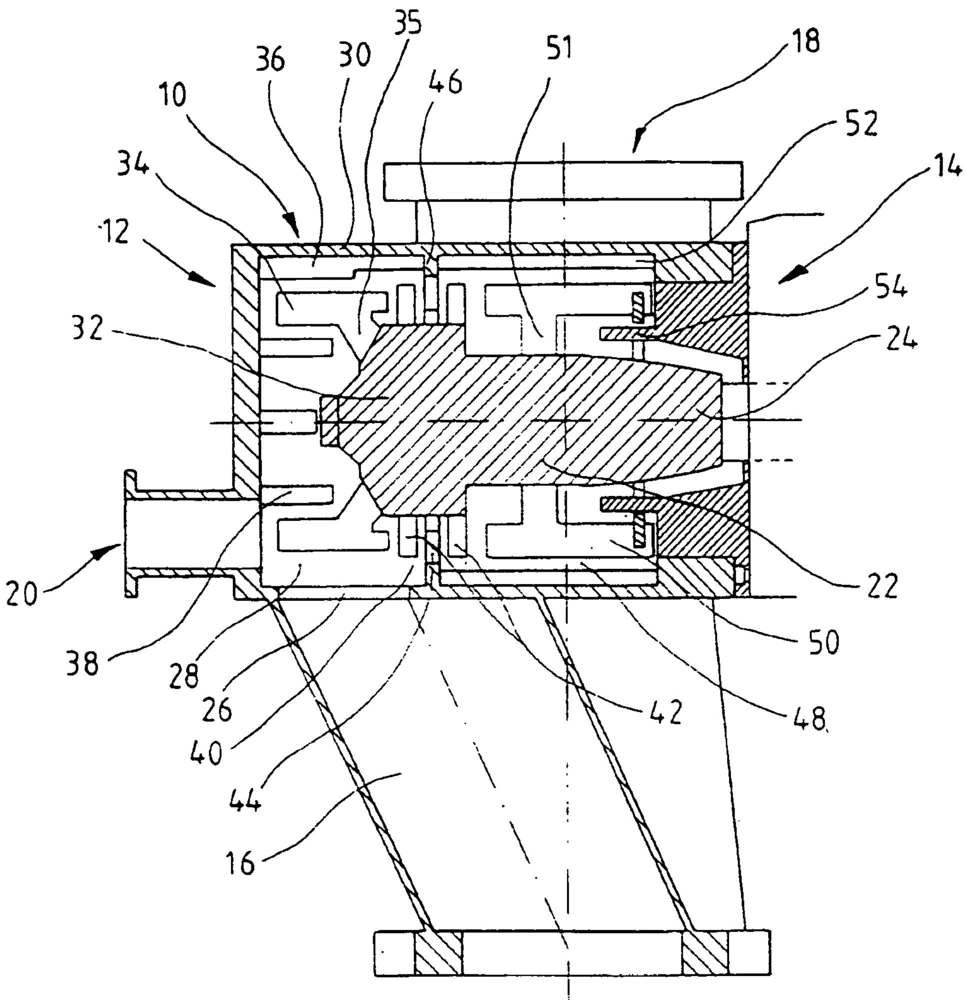
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FIG. 1

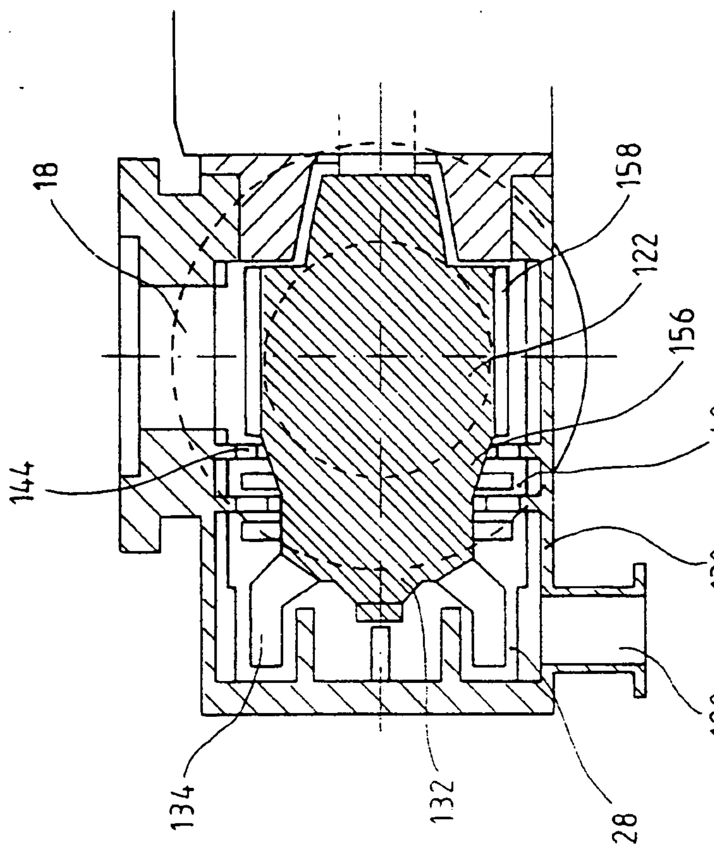

FIG. 2

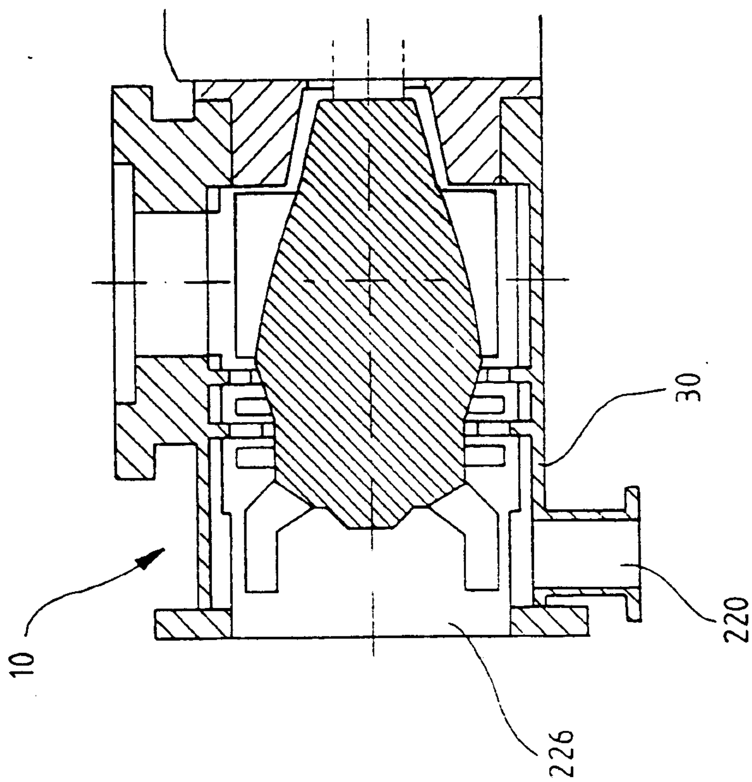

FIG. 3

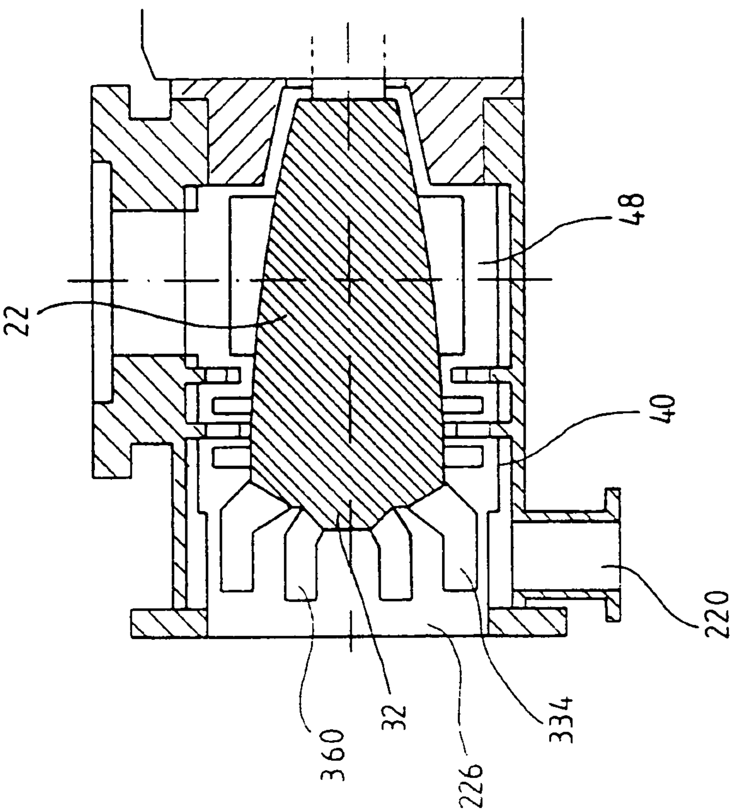

FIG. 4

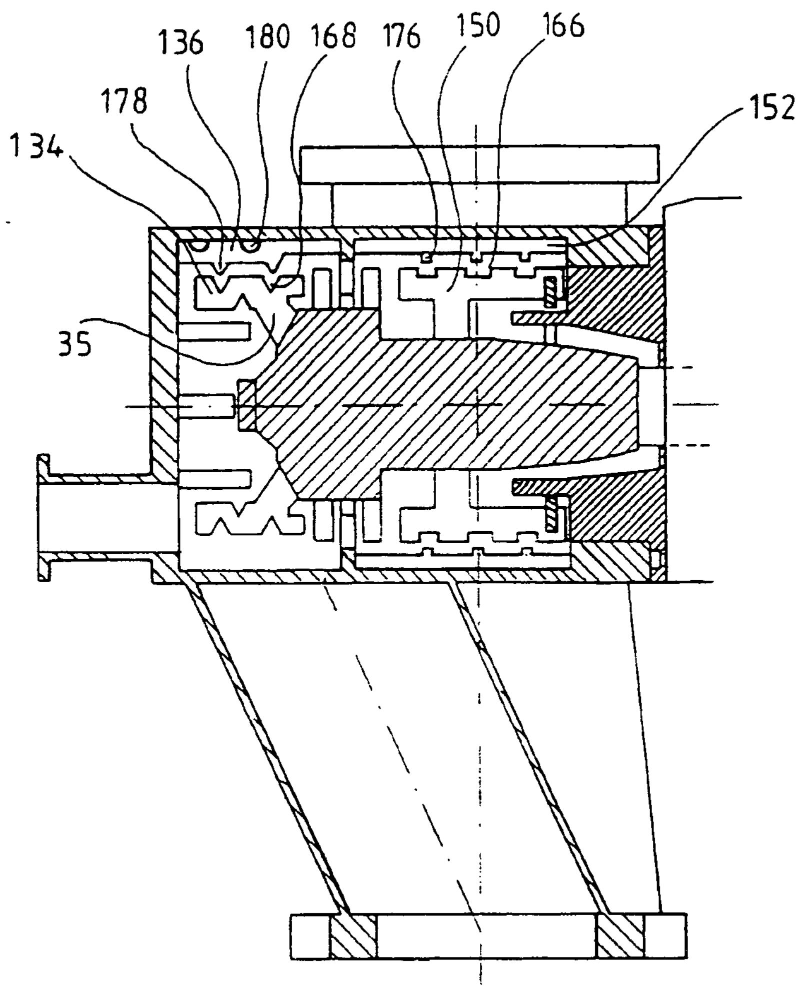

FIG. 5

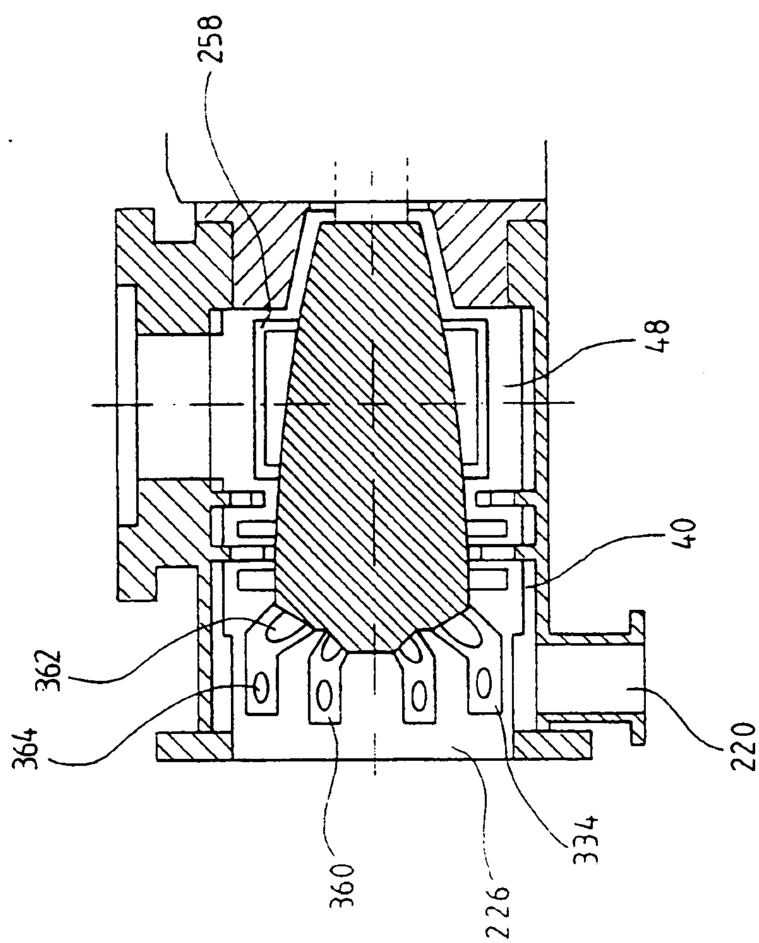

FIG. 6

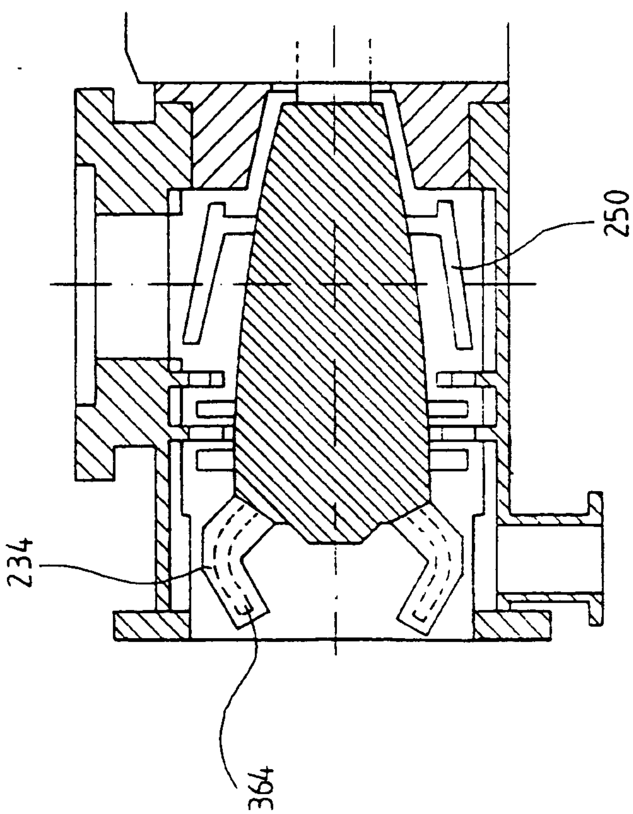

FIG. 7

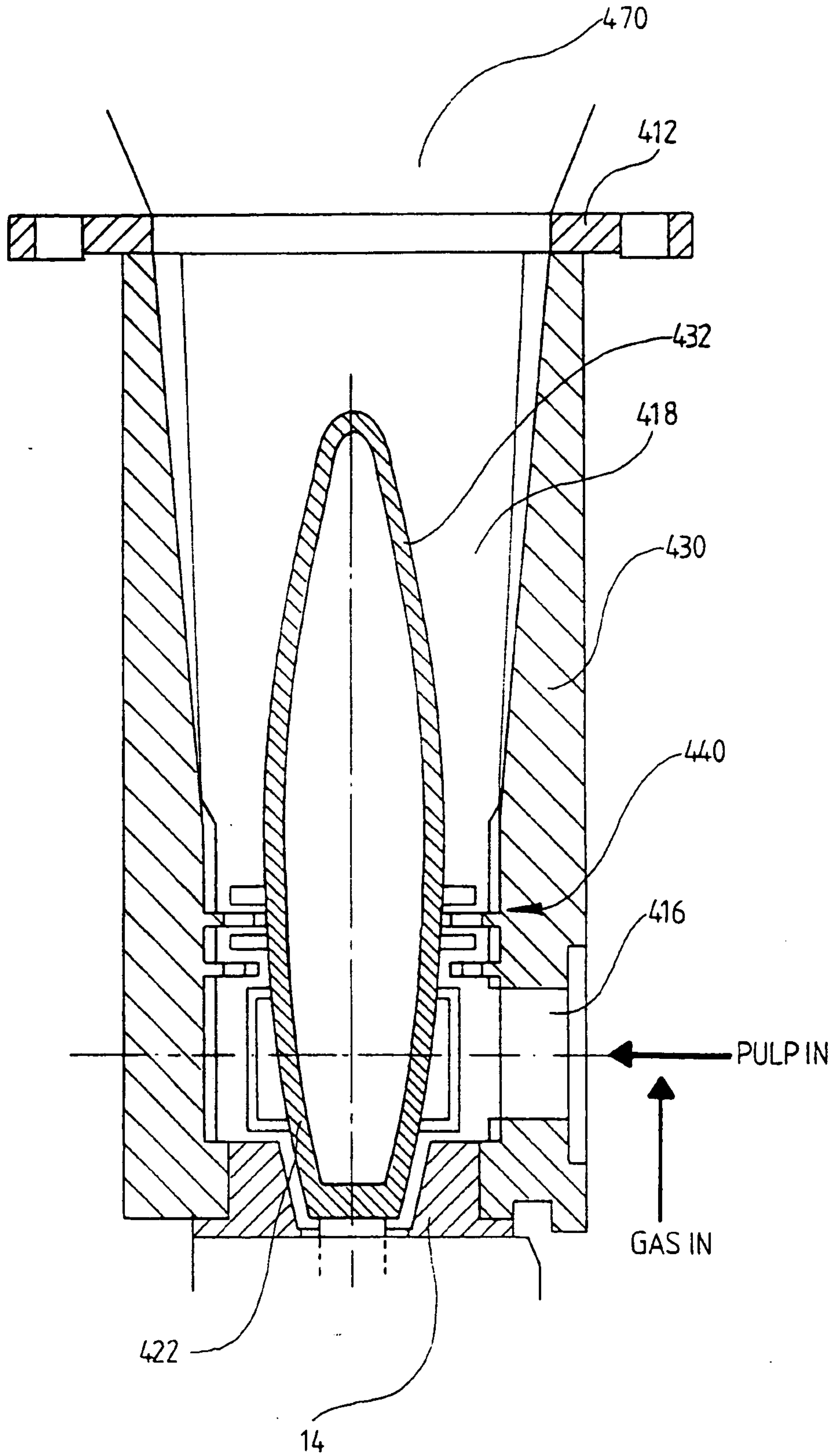

FIG. 8

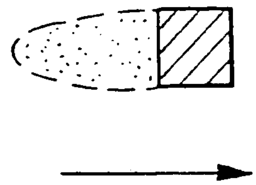

FIG. 10

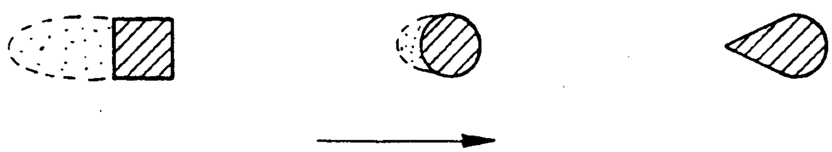

FIG. 11

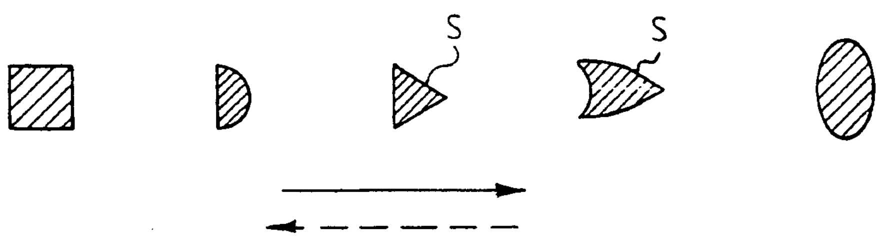

FIG. 12

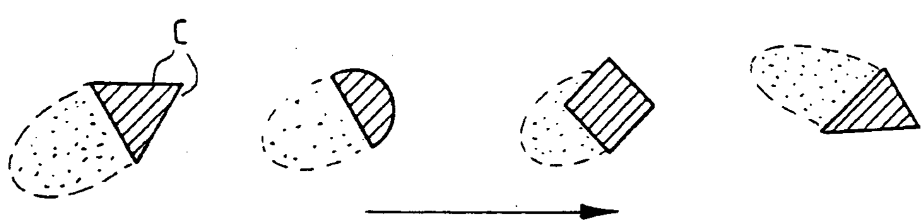

FIG. 13

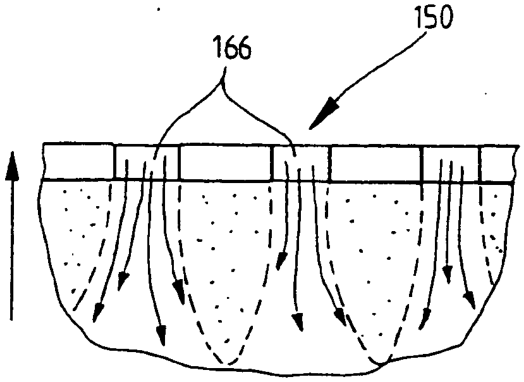

FIG.14a

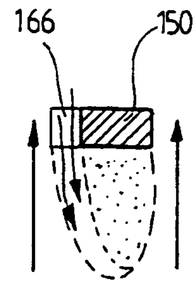

FIG.14b

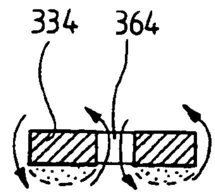

FIG.14c

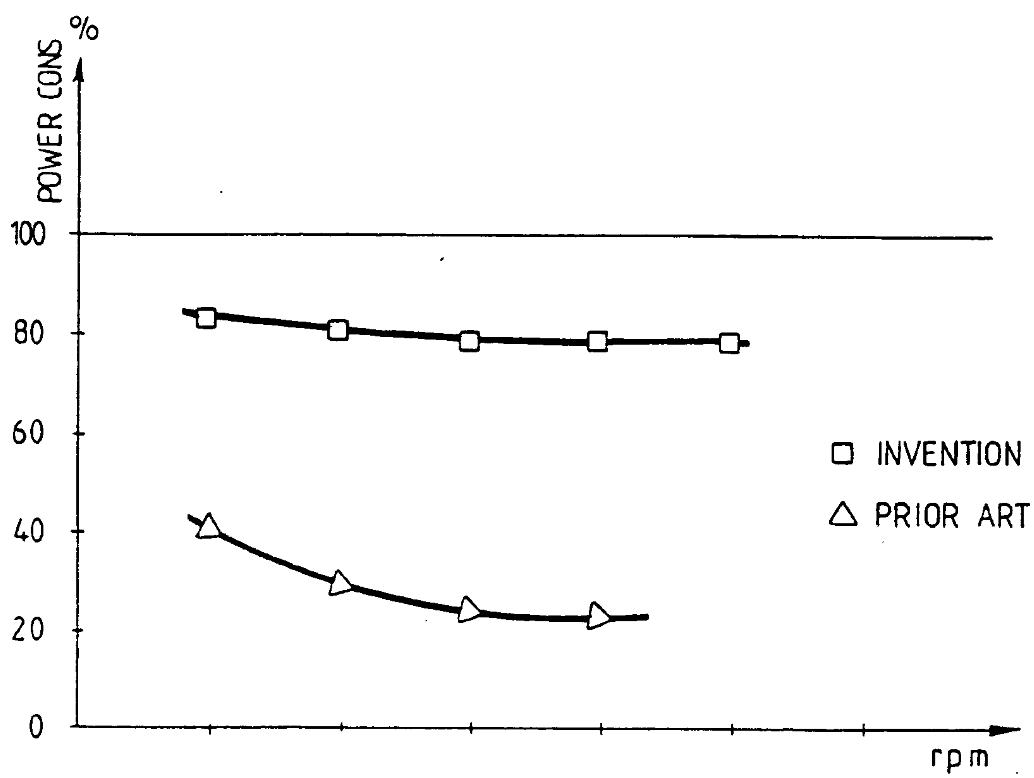

FIG. 15

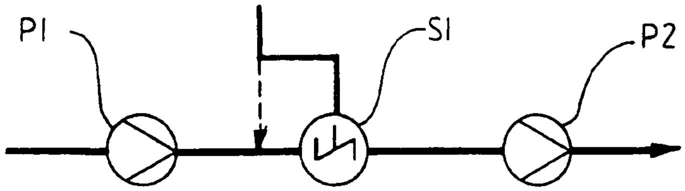

FIG.16 a

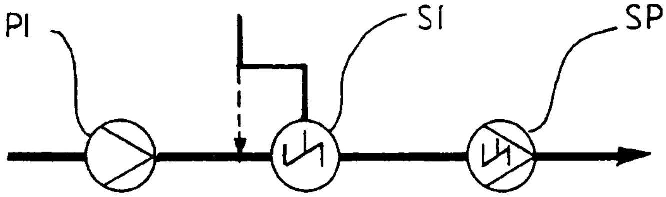

FIG. 16 b

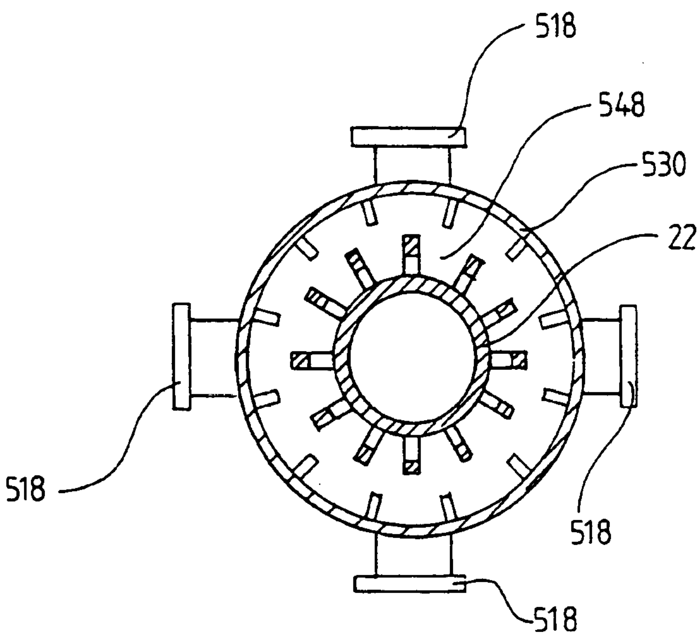

FIG. 9

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 10 0973

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A,D	WO-A-93 07961 (AHLSTROM) ---	1,9	B01F3/04 B01F7/04 D21C9/10
A	US-A-4 908 101 (FRISK) ---	9	
A	FR-A-1 400 173 (KAMYR) ---		
A	DE-U-88 07 080 (IKA) ---		
A	WO-A-93 04772 (SUNDS) -----		

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

B01F
D21C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	21 March 1995	Peeters, S

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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